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SOME PRELIMINARY EXPERIMENTS AND A MODEL OF INFORMATION-SEEKING STYLE OF RESEARCHERS*

Albert H. Rubenstein
Professor

Richard W. Trueswell

Gustave J. Rath
Associate Professor

David J. Werner
Research Assistant

Department of Industrial Engineering
Northwestern University

Albert H. Rubenstein *has his B.S. from Lehigh and his M.S. and Ph.D. from Columbia, all in Industrial Engineering. He was on the Industrial Engineering staff at Columbia from 1950-53 and on the faculty of the School of Industrial Management at MIT from 1953-59. Since 1959 he has been Professor of Industrial Engineering at Northwestern University. He has worked in the chemical equipment industry and in management consulting, specializing in organization and economics of Research, Development, and Engineering. His research interests are in organization theory with special reference to R and D. He is editor of the "Transactions on Engineering Management" of the Institute of Radio Engineers—a journal devoted to research-on-research—and the author of many articles on research management, organization theory, and communications. He is Director of Studies for the College of Research and Development (COLRAD) of The Institute of Management Sciences, a contributing reviewer to "International Abstracts in Operations Research," and a member of the Advisory Committee on Economic and Statistical Studies of Science and Technology, National Science Foundation.*

Gustave J. Rath *is an Associate Professor at Northwestern University. He is currently teaching graduate and undergraduate courses in data processing and simulation; synthesis and design of complex systems; system simulation and systems implementation engineering, including man-machine systems design. He is active in behavioral research and Project Director in the Program of Research on the Management of Research and Development, and Project HINDSIGHT. Dr. Rath received the Ph.D. in Industrial Engineering and Psychology from Ohio State, and has accomplished extensive and vital research programs for Wright Air Development Center, Ohio State's Laboratory of Aviation Psychology and Operations Research, and IBM Research Center. He has been Manager of Government Financial Analysis for the Raytheon Corp., and Consultant for the Department of Defense as a member of the Subpanel on Design and Use of Man-Machine Systems.*

In this Program of Research on the Management of Research and Development which is in progress at Northwestern University,[1] questions of the information-seeking behavior of scientists and engineers keep reappearing. For example, our research in the area of idea flow, which is concerned with the communication of ideas in research and development, points up the

*This work is being supported by the National Aeronautics and Space Administration under Grant NSG-495 and the Public Health Service under Grant LM 00098-01.

1a) *Program of Research on the Management of Research and Development,* Annual Report 1965-1966 and Program Summary 1960-1966, Department of Industrial Engineering and Management Sciences, The Technological Institute, Northwestern University, Evanston, Illinois, September 1966 (66/32).

b) Rubenstein, Albert H. "A Program of Research on the Research and Development Process," *IEEE Transactions on Engineering Management,* Vol. EM-11, No. 3, September 1964. pp. 105-112. (63/7).

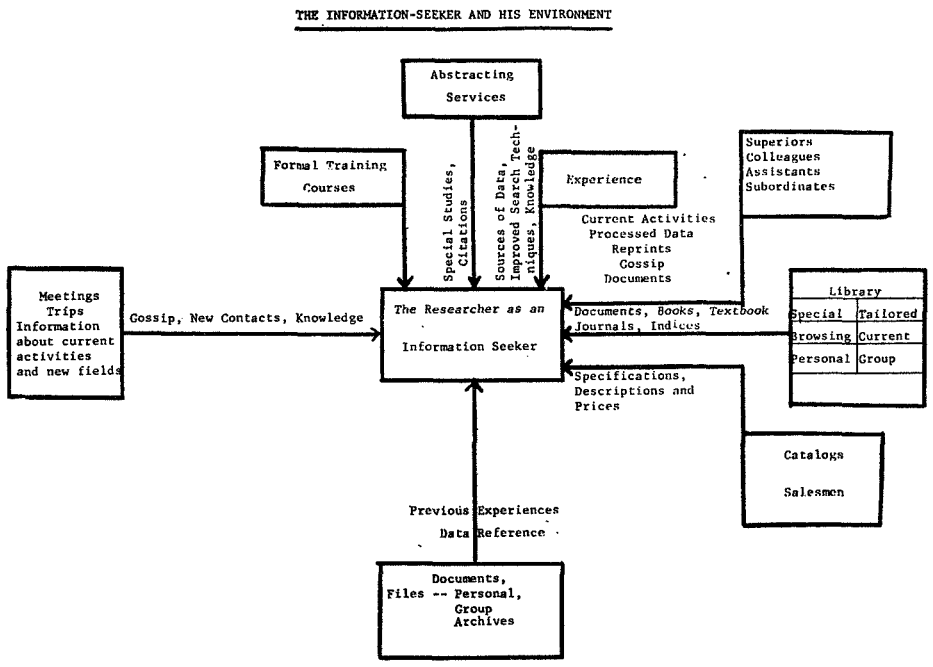


Figure 1

need for better knowledge of information-seeking behavior.

Our research on project selection, development of new technical skills, R and D in developing countries, and transition between various phases of the "R and D-to-application" process also require better knowledge of the information-seeking behavior of people in R and D.

Consequently, as one of the 12 projects in our overall research program, we have undertaken a long-term study of the information-seeking and information-using behavior of R and D people.

One of the important activities of the researcher is dealing with his information environment.[2] His information-seeking behavior involves interaction with many formal and informal sources including such traditional sources as libraries and abstracting services. Figure 1 is an abstract view of "The Information-Seeker and His Environment." The diagram lists many of the people, organizations, and services which yield the researcher a wide variety of information.

One major focus of this research project, which we call "Infosearch," is concerned with how researchers use information services which are available and the conditions which affect their use. Ultimately, we would like to be able to predict, for a given researcher within a specified organization, what specific sequence of services he will use to get an answer to an operationally-defined specific type of question. Our goals at this stage are more modest. We are looking for general patterns of information-seeking behavior. In project "Infosearch," we are not currently addressing the larger question of how information-seeking behavior affects research productivity. We are considering doing this in a later phase of the project.

Here we are focusing on the variety of existing and newly developing information services. We are trying to determine how and under what conditions a researcher chooses among them. Individual differences, which we call "style," ultimately determine the way in which people deal with their information environment and the manner in which new services are tried and accepted.

"Current Awareness" and "Searching" as Information-Seeking Behavior Patterns

A person learns, through his experience and conditioning, that certain information sources and services are useful. His use of these sources and services de-

[2]Rath, Gustave J. "Research on the Management of Research and Development: Initial Steps Toward Studies of the Informational Behavior of Scientists and Engineers," A chapter in *Information Systems Sciences: Proceedings of the Second Congress*, John Wiley and Sons, 1965. pp. 435-445. (65/5).

pends on the reward he has received from using them and his expectation of future rewards. For example, a person might feel that it is important to read *Science* or *Index Medicus* regularly and *Scientific American* once in a while. Some characteristics of the current awareness behavior pattern are as follows:

1) it is highly stable (changing slowly due to external factors or learning)
2) it occurs frequently
3) it generally precedes search (it is an independent behavior pattern and may serve as a basis for initiating a search)

The high frequency of this behavior pattern and its stability require that it be sampled in a different manner than specific search behavior aimed at finding a particular piece of information or solving a problem.

Current awareness may affect specific searching behavior in a number of ways. It gives the searcher general knowledge which he may use to meet the requirements of a specific search. It develops the awareness of sources which the searcher may use. It may be the occasion of serendipitous events, related to an interrupted or long-term search.

"Searching" behavior patterns, which our present study centers on, are currently assumed to have the following characteristics:

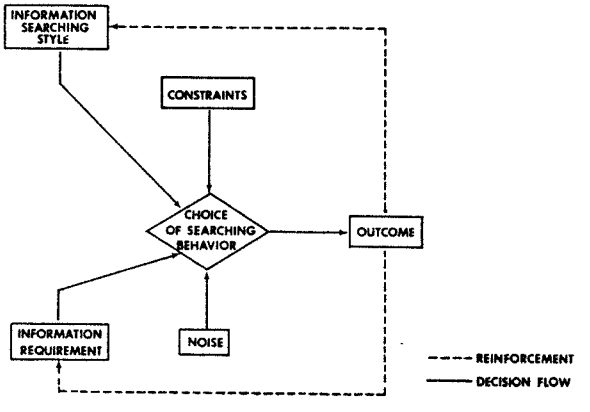
1) they must be learned
2) they are stable over a long period; "unlearning" or forgetting eliminates specific components of a search pattern
3) they are the product of a reinforcement phenomenon
4) they have the structure described by traditional "stimulus-response" learning theory
5) cognitive decisions are made according to subjective expected utilities

An information-seeking behavior pattern must have been used at least once by a searcher before it enters his repertoire. Obviously, one must use a new information service for the first time. Whether or not the first reinforcement of a service is negative or positive determines how it is ultimately incorporated into a person's information-seeking pattern or "style". Information-searching starts with the need for an explicit item of information or items from some general information class and an expectation of finding them. One goes through a series of steps trying to find the information which will satisfy this requirement. Obviously, in the process of carrying out one's search, one may be diverted for many reasons, including switching to other searches. Using the terms of behaviorism, information-searching is a stimulus-response sequence where one has learned that for a certain perceptual (stimulus) environment there is an adequate set of responses including contingencies that may occur. The previously mentioned behavior pattern—current awareness—seems to be more like an operant behavior in which a general set of responses is generated. The responses which pay off are reinforced, and those which do not are extinguished.

A search for information has the following starting point: someone has an informal or formal question and has a need for technical information. Finding the boiling point of a substance, finding out whether one can synthesize a certain chemical, or finding out the reaction time of a man to certain stresses, are specific instances. General instances might be the need to learn about a new theory or to understand a new concept.

A conceptual model of searching behavior will now be discussed. Figure 2 presents "A Simplified Model of Information Searching Behavior." The first two major components of this model are: *information-searching style* which reflects how an individual habitually searchers, and *information requirement* which reflects a need for information. They are the inputs to the *choice of searching behavior* modified by the *constraints* and environmental *noise*. The *outcome* of the search feeds back to affect future search behavior of the searcher, as well as the filling of the information requirement.

This model is an outline of the more detailed mod-



A SIMPLIFIED MODEL OF INFORMATION SEARCHING BEHAVIOR

Figure 2

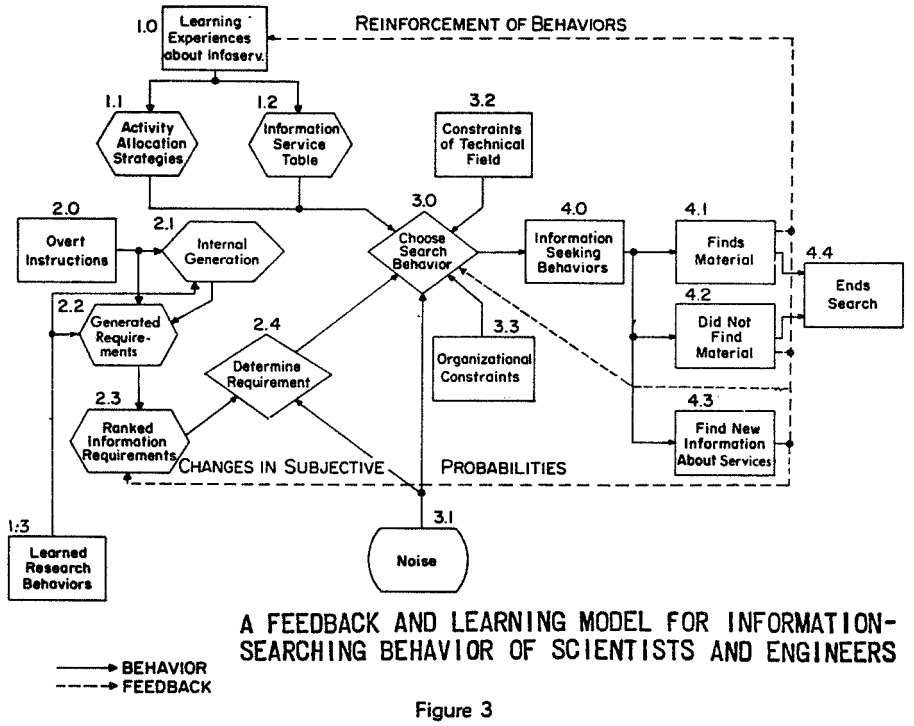


Figure 3

el of Figure 3. Several key concepts are used in the development of the model; some of them are:

1) Searching style is a stable, long-term behavior pattern.
2) The researcher learns to decide how much time should be spent on information-seeking, as compared to other activities.
3) The researcher learns what to use specific services for and the cost of using them.
4) The researcher determines his need for items of information, knowledge or documents, using subjective expected utilities.

Current awareness behavior is excluded from this model.

Figure 3, a more detailed version of Figure 2, is a more complex "Feedback and Learning Model for Information-Searching Behavior of Scientists and Engineers." Each section of the following discussion is keyed by a numbering system to the diagram. We are currently developing propositions to be tested, relating to the various steps in the process.[3]

Section 1.0 through Section 1.3 deals with the development of time allocation strategies and one's searching style.

[3]Rubenstein, Albert H. "Timing and Form of Researchers' Needs for Technic laInformation," *Journal of Chemical Documentation*, Vol. 2, No. 28, 1962 (62/2).

1.0 Learning experiences about information services.

Through a lifetime of learning experiences, the researcher is reinforced for using certain services and, depending on whether the reinforcement is positive or negative, is apt to use them more or less.

It takes a fairly long period of time after the entry into a new environment to learn the use of the information services which are available in that environment. One may acquire years of experience without encountering new information services, unless there has been a change in the state of the art, or when one changes jobs or locations within an organization or field. Changing fields or organizations should lead to a much greater source of new experiences, but these new experiences require time before they change one's information-seeking behavior It takes a while before one has the opportunity and the need to use most of the unfamiliar services in a new organization, or a new field.

1.1 Activity allocation strategies.

One of the major considerations a researcher faces over a lifetime is how much activity should be allocated toward information-searching behavior. This allocation involves, among other things, the phase of R and D one is engaged in. Time competition exists between

doing research, being involved in promotional activities, administration, and other activities. This will affect the amount of effort and time which the researcher can devote to seeking information, and might serve to defer certain searches which require a large commitment of time and effort by the researcher.

1.2 Information service table.

The "information service table" shows for each learned information service: 1) the type of information that it is normally used for (e.g., a dictionary may be used for definitions, a computer for extracting information from data), and 2) the cost of acquisition—personal cost, money cost, and time delays for each one.

1.3 Learned research behavior.

Experiences stemming from actual research work and training for research lead an individual to develop patterns of carrying out research. These patterns influence the steps to be followed.

2.0 Overt instruction.

The start of a search sequence might be stimulated by a request from a supervisor, question from a colleague, or a need for information on a current task. Simultaneously, some or all of the information required to assess the expected utility of the information is generated.

2.1 Internal generation of requirements.

The overt instruction, in many cases, leads to internal generation of substeps. For example, if one has asked for information on a specific chemical process, one might want to find books and reports that deal with the subject. If one is interested in applications of a new technology, one might want to learn something about the state of the art before looking at manufacturers' catalogs. The internal generation of the many substeps is a function of the detailing of the research process by the researcher, other covert self-instruction, and the substeps that he usually follows in any information-searching problem. The utilities of the internally developed requirements are developed. The phenomenon of changing searches in midstream may occur when one finds a title of an unexpected book or article that leads him to drop everything if it seems to have some highly valued information for another requirement.

2.2 Generated requirements.

Having the overt instruction and the internally generated instructions, one then generates a set of specific information requirements; that is, one may need a copy of a specific journal article or a book which is likely to contain a given formula. Any missing utlities are generated at this time.

2.3 Ranking information requirements.

All the required information associated with the request has a subjective probability of being found, based on the prior experience of the searcher. This may be modified as a function of time. The utility of finding the information may be less subject to modification. At the end of the search, it may be modified. Subjective expected utility (SEU) is the main ranking factor. It is the product of the probability and the utility of finding the information. That is, items with a low probability of being found which have a high payoff or those with a high probability of being found but having a low payoff are much less apt to be searched for than those items which have both a high utility and a high probability.

After every search, the experience with new services or the previously used services could change one's expectation of finding the desired information. If the expectation changes, the SEU would be recomputed and a new ranking of information requirements would occur. The reranking could explain many unexpected changes which are observed during a search.

2.4 Determining information requirements.

The subjective ranking of the current set of information requirements influences the order of items to be searched for. Furthermore, noise and environmental events may temporarily affect the probability or utility of a given information requirement over a period of time.

3.0 Choosing search behavior.

Given a specific requirement, the pivotal choice is what search method will be attempted. This depends on many factors, some of which have been discussed. Others are the field one is working with, current organizational constraints, one's prior experience with particular information services, and one's current information requirements. All of these influence the decision.

One might want to use a computer to aid in the search, but if the budget and organization do not provide for one, this restricts the choices. Within these constraints, the searching techniques which one knows and the requirements he has are combined to make the decision on which search technique will be tried next.

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A major assumption is that the choice of behavior is according to a rational model. The relative values of the utilities, probabilities and expectations may be idiosyncratic to a given researcher, but they are generally consistent, unless acted upon by some of the factors discussed above.

3.1 Noise.

Sporadic random requirements and choices may occur. Recency or an overwhelming "non-information-oriented" behavior may occur. Recency is the concept that the last thing a person did is the most recent thing in his mind. Noise may consist of recent experiences which change one's pattern of behavior. Going to the library because of the pretty librarian may affect a specific search decision, but it is not part of the model unless it significantly affects his information service table (1.2).

3.2 Constraints of the technical field.

Certain fields may not have particular services. For example, in the human factors field there is no computer-searching available because there is no specifically designed data bank directed toward this field. In several medical specialties one could use MEDLARS* for computer-searching. Thus, the researcher who changes fields or is becoming inter-disciplinary may find major constraints on his style.

3.3 Organizational constraints.

Similar to fields, wide discrepancies exist among organizations regarding available and allowable information services.

For reasons of resources, personnel, dollar cost, security, prestige or tradition, the use of certain services may be excluded. A company might not use a service offered by a competitor. A scientist may not be allowed to attend meetings because of military security.

4.0 Information-seeking behaviors.

The searcher carries out the chosen behavior as soon as practicable. Obviously, another set of time-competitive activities must be reckoned with.

4.1 Searcher finds material.

When a searcher finds what he needs, he has reinforced some of the antecedent activities.

4.2 Searcher does not find material.

Not finding the material may negatively reinforce some of the antecedent activities.

*National Library of Medicine Medical Literature Analysis and Retrieval System

4.3 Searcher finds new information about services.

One of the important benefits of searching is learning about new services and sources. The existence of these new services and sources may become part of the repertoire or one may discover the existence of needed but unsearched for material.

4.4 Search ends.

The ending may be caused by either search-related or non-search-related factors. A lack of resources or time may be as decisive as finding the desired material or finding out that the material doesn't exist. Among the researchers studied so far, the preferred style seems to be short sequences over long ones. After each information-searching step has occurred, the decision to continue to the next step is made in the same manner as that of stopping the search. Each step of a search involves most of the model of Figure 3.

One long-term objective of the study is to develop criteria or measures of effectiveness which may be used to evaluate alternative information systems. Some tentative ones[4] are:

1. Completeness of response to the information inquiry.
2. Noise ratio = percent relevant material / percent irrelevant material. What amount of noise is desirable? What effect does eliminating noise have? That is, does it eliminate accidental finding of information and eliminate the benefits of browsing?
3. Allowed interacting behavior. What interaction should occur between the system and the user? What effect does the interaction have on the system performance? People do not always know what they want or are unable to formulate the question. Interaction may be necessary to specify the information needed.
4. Time required to obtain answer.
5. Response cost.
6. Effort of inquiry. How much time and effort are required of the scientist in using the system?
7. Breadth of system. What range of fields and sources are covered?
8. Growth and decay. How does the system change over time?

These criteria could be described as proximal or indirect measures of effectiveness, whereas the following can be described as ultimate measures:

[4]Werner, David J. *A Study of the Information-Seeking Behavior of Medical Researchers*, Master of Science Thesis, Northwestern University, Evanston, Illinois, December 1965 (65/35).

TABLE I

A TEN-YEAR PROGRAM OF RESEARCH ON INFORMATION-SEEKING BEHAVIOR

	1965 1966	1967 1968 1969	1970 1971 1972 1973 1974
PHASE	PILOT	ANALYSIS OF EXISTING BEHAVIOR	CHANGING FUTURE BEHAVIOR OF RESEARCHER
PURPOSE	DEVELOP TECHNIQUES OF MEASUREMENT DEVELOP MODELS AND THEORY	DESCRIBE THE CURRENT INFORMATION SEEKING BEHAVIOR AND EFFECTS OF CHANGING INFORMATION SERVICES	TEST THEORY OF INFORMATION SEEKING BEHAVIOR BY CONTROLLED ORGANIZATIONAL AND BEHAVIORAL CHANGES
TECHNIQUE	INTERVIEWS OPERATIONAL EXPERIMENTS	OPERATIONAL EXPERIMENTS WITH SPECIFIC AND LIMITED SERVICE	CONTROLLED CHANGES CLINICAL INVESTIGATIONS OPERATIONAL EXPERIMENTS

Quality and quantity of research output.
Effort and worth to users.
Effort and reward to sponsors of the research.
Effort and reward to the society.

The experiments described below are part of a projected ten-year study of the information-seeking behavior of researchers. Like many of the other projects in our overall Program of Research on the Management of Research and Development, this study is a subprogram of its own, made up of a number of substudies growing out of each other and, hopefully, cumulating into significantly increased understanding of the phenomenon.

Table I gives the outline of a projected "Ten Year Program of Research on Information Seeking Behavior." The program has three major phases: pilot studies, the analysis of current behavior, and the analysis of methods by which research behavior is changed.

In the pilot phase, the feasibility of measuring certain information-seeking behaviors in real-time had to be tested and techniques for data collection had to be developed. The pilot study took two years, 1965-1966.

The second phase deals with the question of whether well-organized innovative services which lead the state of the art will affect the information-seeking behavior or style of the researchers involved when presented in the typical manner used today. The two components of the style which are of interest here are: 1) the total amount of time spent in interacting with the total information environment, and 2) the pattern of search which involves use of a specific combination of information services to meet a specific type of requirement. Our working hypothesis here is that except for a little learning that occurs in the reinforcement stage of the researcher (see Figure 3), there are no major changes made in individual style by the introduction and subsequent removal of a new information service, as currently practiced in R and D organizations.

The third phase will also involve providing a service which is technologically sound and potentially useful. But it will involve, in addition, the manipulating of organizational and psychological variables through training. We hope to learn if, by this method, we can increase the possibility of a new service being accepted and adopted as part of the information-seeking style of the researcher.

Table II indicates the kind of people involved in the studies so far and the techniques used.

Figure 4 illustrates our approach, which is a combination of model and theory building, empirical investigations and operational experiments. We start with the literature and the current work of ourselves and other, develop propositions and taxonomies, prepare sites, carry out pilot studies and experiments, refine the models and propositions, and so on through the cycle.

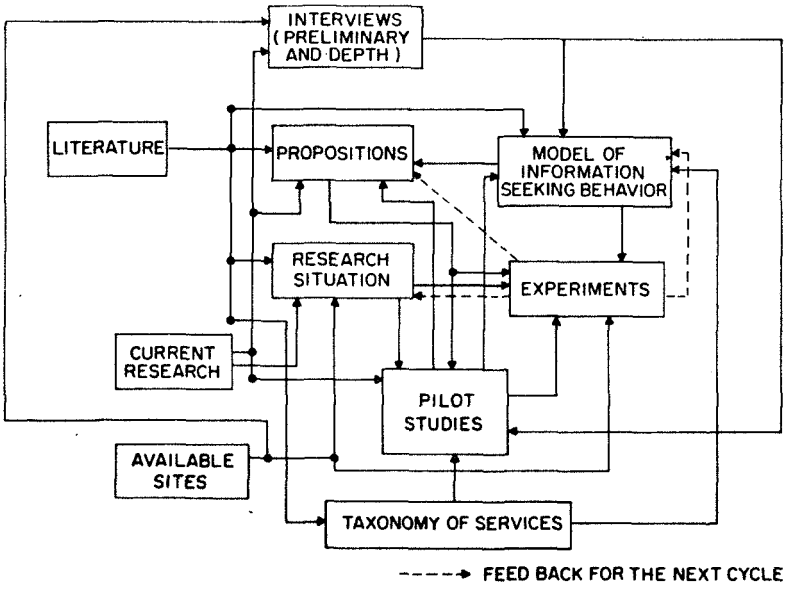
The methodology centers around an input from the literature and current research within a specific re-

TABLE II

FUNCTION, SUBJECTS AND SERVICES USED IN STUDIES OF THE INFORMATION-SEEKING BEHAVIOR OF RESEARCHERS

FUNCTION	SUBJECTS	INFORMATION SERVICE	YEAR
PILOT OPERATIONAL EXPERIMENTS	MEDICAL RESEARCHERS	MEDICAL LIBRARIANS	1965
OPERATIONAL EXPERIMENTS	X-RAY CRYSTALLOGRAPHERS	PACKAGE OF SERVICE REQUESTS	1965-66
PILOT INTERVIEWS	US GOVT. MANAGERS SCIENTISTS AND ENGINEERS	N/A	1965
PILOT OPERATIONAL EXPERIMENTS	ONCOLOGISTS	FACSIMILE TELEPHONE TO INFORMATION SPECIALISTS IN RESEARCH LIBRARY	1966
OPERATIONAL EXPERIMENTS	ONCOLOGISTS AND CARDIOLOGISTS		1966-68

search situation which includes the sites, subjects and technology which are to be studied. Preliminary activities including interviews, pilot studies, and the development of taxonomies have allowed us to set the stage for a series of experiments. The experiments are designed to increase our understanding of a model of information-seeking behavior through the use of propositions which, in turn, are subjected to testing by the experiments. The empirical studies and operational experiments, combined with the theoretical analysis and model building are the essential features of this research, where the object is to better understand in-



METHODOLOGY OF THE PROGRAM ON INFORMATION SEEKING BEHAVIOR OF SCIENTISTS AND ENGINEERS

Figure 4

formation-seeking behavior of the researcher.

The balance of the paper describes the studies we have done to date.

1. *Some preliminary explorations of information-searching styles**

A series of exploratory interviews was carried out to explore the gross variation in styles of 28 scientists and engineers. No attempt was made to systematically sample the entire population. As a result of other interviews, several distinctive styles were identified. The typology is not systematic or exhaustive, but only descriptive of the variety of individual styles encountered:

Type 1. The senior scientist, "entrepreneur," who uses sources he believes to be authoritative and has his own information network.

Type 2. The senior scientist-professor, who is writing summary and review articles. He is distrustful of some primary and most secondary data sources (e.g. handbooks), and therefore he carefully selects from among primary sources the data he uses.

Type 3. The senior scientist-administrator, who is attempting to maintain his surveillance over a range of technological activities, through sporadic use of the literature including state-of-the-art articles.

Type 4. The senior technologist-administrator, whom technology has by-passed and who does not devote any significant time in search for technical and scientific information.

Type 5. The technologist-project engineer, who is concerned with specific development problems and who uses action and personal channels.

Type 6. The scientist-professor, who uses the broad repertoire of academic, personal and institutional services and channels.

As we define it for this study, *information-seeking style* represents a combination of knowledge about in formation services and sources and search strategy which an individual has acquired over his lifetime and is using at any given time. That is, style is the product of a long-term learning process, and at any time it represents the net cumulative learning a scientist or engineer has acquired to date.

A search occurs when one needs some specific information and one either does not know with certainty whether it exists or where it can be found. A need includes a utility for the information and an expectation of finding it. Information-seeking style, then, consists of a set of decision rules regarding the choice of and sequence of using information services and the strategy of searching for the desired information.

The interview data include descriptive details on the organizational setting and background history of each person, a description of their work activities, their information search patterns and their information experience.

2. *A pilot study of a medical research team*

Tables III-VIII contain some of the results of our pilot operational experiment with a group of four medical researchers working in a particular specialty. It is described in full in a Master's thesis by David Werner.[5]

The researchers were interviewed and their information environment was carefully described. A telephone tape-recording system was installed after initial interviews were completed. After they had been using the telephone system for several weeks to report their information-seeking experiences to us, two types of "diary" cards were used to record searches. The operational experiment consisted of assigning a technical librarian to work with the group. The major set of data collected was the detailed sequential transcripts of over 50 searches. The research centered on specific and exhaustive searches. This study was a necessary precursor for the full-scale operational experiment which we are now preparing to conduct (1966-7).

Table III shows the distribution by number of steps for the 51 searches completed during the period of observation. It shows, for example, that over 80 percent of the 51 searches were completed in one or two steps.

TABLE III[6]

Distribution of the Number of Steps for Each Search Type for Completed Searches*

Number of Steps	Percent Completed	Cumulative Percent Completed
1	52.9	52.9
2	27.4	80.3
3	9.8	90.1
4	2.0	92.1
5	3.9	96.0
6	2.0	98.0
7	2.0	100.0

*Sample size = 51 searches. Incompleted searches are not included.

*Frank Baker and Richard W. Trueswell carried out these interviews.

[5]Werner, loc.cit.
[6]Werner, op.cit., p. 66.

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Table IV shows the distribution of the average number of steps for each type of search. Only completed searches are included.

TABLE IV[7]

Distribution of the Number of Steps for Each Search Type for Completed Searches*

Object of the Search	Average Number of Steps	Total Searches
Particular Document	1.7	7
Definitional Data	1.0	4
Specific Facts	2.1	9
Methodology or Equipment	2.5	11
Background Information	2.2	13
Bibliography	1.0	7

*Sample size = 51 searches. Incompleted searches are not included.

Table V gives some data on the sequence of steps which the medical researchers followed. It is notable that they generally move from a simpler to a more complex technique if you rank them (roughly) in terms of required effort.

If we pursue the searches further, we find that in some cases as many as seven steps are involved.

TABLE V[8]

Relationship Between First and Second Steps*

First Step	Type of Services on Second Step		
	Easier	More Difficult	Equal or Successful on 1st Step
Personal Contact or Use of the Telephone	0	6	3
Use of Personal or Departmental Files	2	4	6
Use of Personal or Departmental Library	1	5	7
Use of the Hospital Library	1	7	2
Library Loan or Write a Letter	0	0	2

*Sample size = 46 searches.

[7]Werner, op. cit., p. 66.
[8]Werner, op. cit., p. 59.

Table VI shows the source most frequently used to obtain information during the first step in information-seeking. The first step varies depending on the information being sought. Thus, in the case of medical researchers seeking a particular document, seven

TABLE VII[10]

Dr. B's Search

	Time	Results
Instructed technician to do the experiment	20 minutes to instruct technician	Technician did experiment which took 4 hours, spread over 2 days.

TABLE VIII[11]

Mrs. A's Search

Source Used	Time	Results
John Crerar Library Card Catalog	10 Min.	Negative
Open Shelves at Crerar Library	15 Min.	Negative
Called a friend at a Chemical Company who was familiar with processes related to Y.	5 Min.	Referred to a Dr. C. at another hospital.
Called Dr. C., but spoke to Dr. D.	3 Min.	Referred to another doctor at the same hospital who recommended Mr. P. at a pharmaceutical house.
Called Mr. P. at the pharmaceutical house.	3 Min.	Yes, X can be treated by process Y. He gave the name of two pharmaceutical houses which had information.

[10]Werner, op.cit., p. 94.
[11]Werner, op. cit., p. 95.

out of nine researchers would first either go to the hospital library or write a letter requesting the document from an outside source. Only two of the nine researchers would be apt to first try personal or departmental libraries.

This example illustrates one of our major propositions, the proposition of specificity, which states that people use specific information sources to search for specific types of information.

Tables VII and VIII illustrate a specific case comparing two alternative means of obtaining the same piece of information. One medical researcher wanted to get some specific information and decided to repeat an experiment to get it, because he did not know how to acquire it from available literature. A medical librarian whom we supplied as an experimental service was able to get it in less total time. A complete economic or value analysis would, of course, require a method of weighing the relative "total costs" of each person's time.

An Operational Experiment on the Information-Seeking Behavior of X-Ray Crystallographers[12]

An operational experiment was designed to determine the effect of giving researchers a set of services which they reported to be both directly applicable to their needs and which they had not previously used or heard about. Ultimately, the evaluation and measurement of new information services will have to be carried out in the natural setting. The knowledge about information-searching behavior which we are seeking requires that researchers be observed and experimented with in their regular working area. Individual factors, organizational constraints, specific subject matter and work phasing will influence the use of services, so studies will require the manipulation of many different alternatives in order to establish their relative utilization and, if possible, their impact. The field of X-ray crystallography was chosen for this experiment be-

[9]Werner, *op. cit.*, p. 48.
[12]Trueswell, R. W. *An Experiment in Measuring Certain Aspects of the Information-Searching Behavior of X-Ray Crystallographers*, Northwestern University, Evanston, Illinois, October 1965 (65/37).

TABLE VI[9]

FIRST STEP OF SEARCH AS RELATED TO THE OBJECT OF THE SEARCH FOR ALL SEARCHES*

First step of the search \ Object of the Search	Particular Document	Definitional Data	Specific Facts	Methodology or equipment	Background Information	Bibliography	Total
Personal contact or Use of the telephone	0	0	[4]	[5]	0	0	9
Personal or Departmental files	2	[3]	1	[5]	1	0	12
Personal or Departmental library	0	1	[3]	0	[9]	0	13
Hospital library	[4]	0	1	1	3	0	9
Library loan or Write a letter	[3]	0	0	0	0	0	3
News Service (Mrs. A)	0	0	0	0	0	[10]	10
Total	9	4	9	11	13	10	56

*Sample size = 56 searches

cause it is a technical research area which spreads across many disciplines and organizations, while being well enough organized so that the location of researchers and information sources and services was fairly easy.

An operational experiment was designed in which, initially, 18 researchers participated. Fifteen subjects completed the study. These researchers were paired as experimental and control subjects within each organization. In some cases, the pairs had close organizational ties; in other cases, they did not. The sample included industrial organizations which either use X-ray crystallography or develop and sell products for the field and nonindustrial organizations which include university, consulting and government activities. The general procedure began with an initial orientation meeting. An initial interview followed, concerned with the researchers' organization and personal information environment. For two weeks, information activity cards and the telephone tape-recorder system were used to record the subjects, information-seeking behavior (current awareness plus specific and exhaustive searches). At the end of two weeks the experimental subjects were given a package of information services. Then, for two more weeks, observation was continued. Final interviews were held with all subjects. Six months after the final interviews, another set of interviews was held.

The package of services which was offered consisted of a series of sealed envelopes; on the cover of each envelope was a sheet describing the contents of the package. The package consisted of the following:

1) A machine search record of the NASA "STAR" system.* The subjects were given a list of terms and were asked to check off on a form those terms on which they wanted a personal search carried out. All the terms dealt with their general field of interest.

2) A special bibliography of dissertations available from University Microfilm, Inc. Subjects were given an order form so that they could obtain such materials free.

3) A copy of *Current Contents* and a copy of *Index Chemicus*. A form was given to the subjects so they could order articles at no cost to them.

4) Copies of the tables of contents of recent journals dealing with crystallography. A form to order articles was provided.

5) A listing of unclassified Argonne Laboratory reports and papers and a form to order copies.

6) A listing of available publications at Argonne. This was included in case the subjects wanted to use the library.

7) A description of the National Referral Center, Library of Congress. Subjects were authorized to place long distance calls to the NRC-LOC.

*National Aeronautics and Space Administration Scientific and Technical Aerospace Reports.

TABLE IX

Use of Information Services by X-Ray Crystallographers

Population	Number of Subjects	Number of Services	% Opened*	% Used
Experimental	9	63	48%	19%
Control	6	42	15%	0%

*Corrected for services already available in organization.

Figure 5 is a picture of the package of services. Each large envelope contained seven smaller envelopes, which, in turn, contained one of the above-mentioned services.

Table IX shows how the X-ray crystallographers reacted to the services supplied. It is notable how few used the services, even though they stated, in advance that the services would be useful to them.

As previously indicated, each experimental subject received a package of services. The third column represents the total number of envelopes (seven services or envelopes per package). The fourth column shows what percentage of envelopes were opened, and the fifth column shows what percentage of services were used. In addition, due to their physical proximity and communication patterns, some "control" subjects also opened some envelopes.

Design of the Current Series of Operational Experiments

Table X indicates the schedule for our current operational experiment.

Figure 6 illustrates the package of information services we expect to introduce experimentally in the next set of experiments. This includes: a telephone for transmitting information requests; a recording system by which requests are sent ahead to the searcher and by which confirmation of request is sent back to the user via a Data Fax transmitter; information sources consisting of libraries and MEDLARS; the media containing desired information; a means of copying the information, and a means of sending the information to the user, either by U.S. Mail or the Data Fax transmitter.

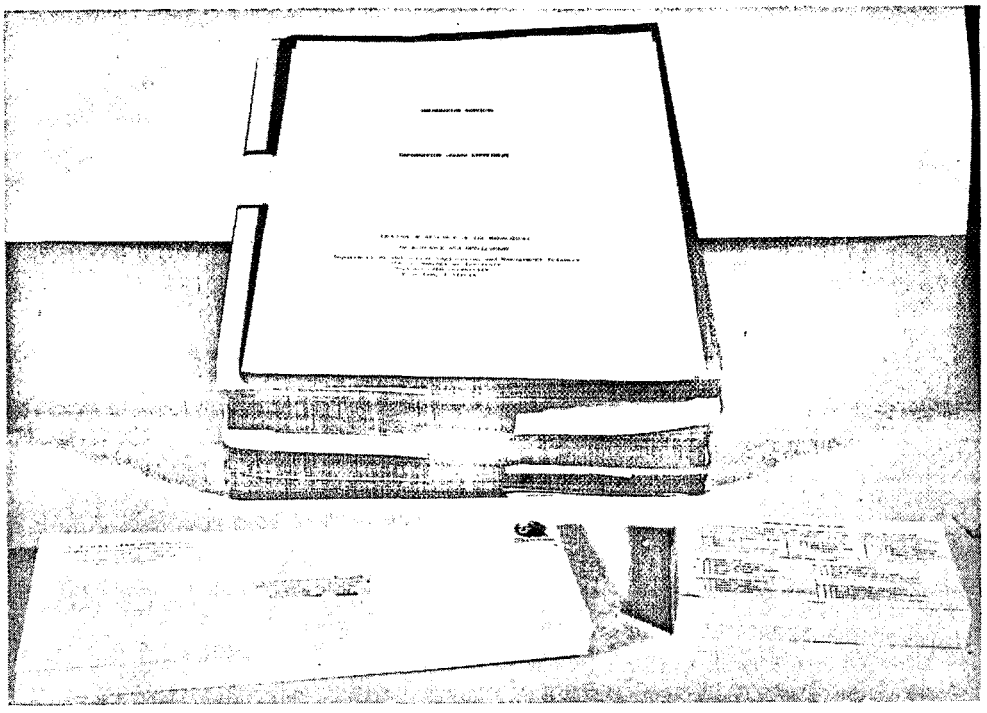

Figure 5

AN INFORMATION SYSTEM FOR THE
INFO-SEARCH EXPERIMENT

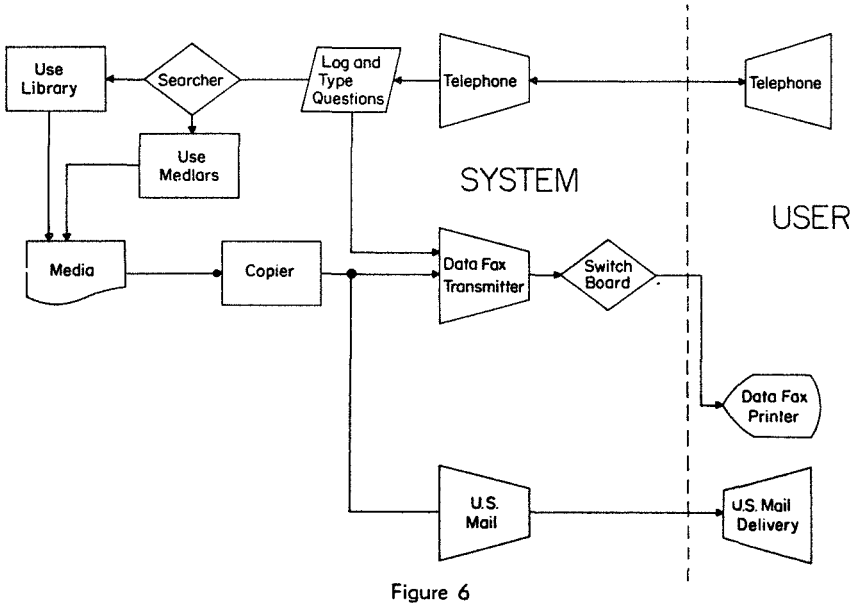

Figure 6

Third Session

TABLE X

EXPERIMENTAL DESIGN FOR EACH GROUP
$4 < N < 11$

Oct. '66 - Mar. '67
Preliminary interview and calibration of info-search behvavior
Mar. '67
2 weeks pretest of data collection instruments
Apr. - Sept. '67
2 1/2 month - 2 1/2 month control - experimental experimental - control
Oct. '67
2 weeks post-test of data collection instruments
Mar. '68
Proximal post-interviews
Oct. '68*
Distal post-interviews

*Additional distal post-interviews are planned.

Figure 7 illustrates on of the information activity cards we are currently using. This is one of our major real-time instruments. In Werner's experiment[13] these cards were filled in at an average rate of one-third cards per day. In Trueswell's experiment[14] these cards were filled out at the rate of four cards per day.

Retrospective Measures of Information-Seeking Style

Figure 8 is one of a series of instruments we are using to try to measure the information-seeking styles of several hundred participants in our studies of the environmental and management factors involved in producing R and D events in connection with military systems. This is related to project HINDSIGHT on which Colonel Raymond S. Isenson reports at this conference.

In this study we are trying to recapture the styles which the participants used at the time of the events—in some cases up to ten years ago. It is difficult methodologically, and reinforces our conviction of the necessity for "real-time" research in most of our studies.[15]

Attempts to Develop Taxonomies

The effort to develop a taxonomy of information services has not been very fruitful. Reviewing past efforts of ours, we used in 1961[16] the categories of: conventional published forms, correspondence and personal visits, bodies of data, methods for getting quick answers to specific and general technical questions, and failure data. A much more extensive listing was prepared and shown in Figure 1 in the initial stages of our experiments.[17,18] Attempts to 'taxonomize' this list were made in 1964 and 1965.[19] This list had 51 items. The major headings were:

1. Indexing service
2. Abstracting service
3. Document depositories (libraries)
4. Document service (journals reviews, tables of contents, etc.)
5. Meetings (conventions, trade shows)
6. Organization service (company sales personnel, company research personnel)
7. Educational service (courses, programmed instruction, UHF-TV)
8. People service (doctor's personnel)
9. Contacts and friendships
10. Personal systems (files, retrieval systems)

For project HINDSIGHT, 26 items are listed in the *Hindsight Field Manual.*[20] The major headings here are:

1. Written
2. Verbal
3. Combinations
4. Method

The critical problem centers on dimensionality. One is simultaneously dealing with knowledge, data, graph, punched cards, journals, books, files, libraries, and mechanical devices. It seems at present that one uni-dimensional taxonomy is insufficient. The problem of how to categorize "a Xerox copy of a journal which

[13]Werner, loc. cit.
[14]Trueswell, loc. cit.

[15]Rubenstein, Albert H. "A Real-Time Study of Information Requirements for Project Selection in Research and Development," Presented to the members of the Internatiolan Federation of Operations Research Societies, Boston, August 1966 (66/28).
[16]Rubenstein, loc. cit.
[17]Werner, loc. cit.
[18]Trueswell, loc. cit.
[19]Rubenstein, Albert H. *Excerpts from Proposal for the Study of the Information Environment of Medical Researchers,* Northwestern University, Evanston, Illinois, January 1966 (66/17).
[20]*Research on Proposition Formation and Field Studies in Connection with Project Hindsight,* Appendix D. Northwestern University, Evanston, Illinois, July 1966 (66/17).

INFORMATION ACTIVITY CARD

INFORMATION NEEDED: _____

_____

WRITTEN SOURCES	LOCATION OF WRITTEN SOURCE	RESULT OF THE ACTIVITY
___ Books	___ Library in this institution	___ Obtained the information needed
___ Handbooks and reference books	___ Departmental library	___ Did not find the information needed but found a lead to another source
___ Professional journals and reprints	___ Personal library	___ Did not find the information needed, but will continue the search
___ Government and Institutional reports	___ National Library of Medicine	___ *Did not find the information needed,* and will not continue the search
___ Unpublished papers	___ Personal files	___ Other _____
___ Vendor materials	___ Departmental files	
___ Index and Abstract publications	___ Colleague's files	
___ Personal notes	___ Inter-library loan	Check this box when you have made the final phone call describing this search. ☐
___ Library aids	___ Bookstore	
___ Other _____	___ Other _____	
VERBAL SOURCES	**LOCATION OF VERBAL SOURCE**	The following steps are not shown because they were *reported* by phone:
___ Colleague from this institution	___ Local phone call	Steps: ___ ___ ___ ___ ___
___ Colleague from other institution	___ Long distance phone call	___ ___ ___ ___ ___
___ Consultant	___ In person, away from your institution	
___ Librarian	___ In person, at this institution	
___ Other _____	___ Other _____	

Points to be covered in making a final report on each search:

Phone number of recorder system: 273-2286

1. Give the number appearing on the card.

   Card Number: _____
2. What was the information needed?
3. Why did you want or need this information?
4. *Describe any unusual steps or events in the search.* Why did you use these unusual steps?
5. About how much time did you spend looking for this information?
6. If you did not find the information needed, how do you plan to proceed without it?

Department of Industrial Engineering and Management Sciences
Northwestern University: Evanston, Illinois

Phone number for inquiries: 492-3467

25-102

You may use the following space to make comments about steps in the search:

Step No.	
___	_____
___	_____
___	_____
___	_____
___	_____
___	_____
___	_____
___	_____
___	_____
___	_____

Figure 7

ORIGINATOR CODE _____ IDENTIFICATION CODE _____

INFORMATION SOURCES QUESTIONNAIRE ON ACTIVITIES DURING THE SPECIFIED TIME PERIOD

SPECIFIED TIME PERIOD:

_____

TO

_____

INSTRUCTIONS

1. From this list, select the type of scientific and technical information which you needed most frequently. Write the name of this type of information in the box above column I.

   Concepts and theory
   Design techniques
   Experimental processes
   Math aids and formulas
   Performance characteristics
   Production process and procedures
   Raw data
   Specifications
   Technical status
   Test processes and procedures
   Utilization
   Other* _____

2. Now go back to the list. Choose the second most frequently needed type of information. Write the name of it in the box above column II.

3. Now go back to the list again. Choose the third most frequently needed type of information. Write the name of it in the box above column III.

4. You should now have the box above each of the columns filled.

5. Now, for the type of information you have placed above column I, indicate the importance of the information sources in finding that type of information by placing a check mark in the appropriate space. Only consider those sources you used.

6. Repeat step 5 for columns II and III.

*Specify the sources if you make an entry here.

SOURCES OF SCIENTIFIC AND TECHNICAL INFORMATION	I UNIMPORTANT → VERY IMPORTANT 1 2 3 4 5	II UNIMPORTANT → VERY IMPORTANT 1 2 3 4 5	III UNIMPORTANT → VERY IMPORTANT 1 2 3 4 5
WRITTEN:			
Textbooks			
Scientific Books			
Handbooks & References			
Professional Journals			
Technical Magazines			
Trade Magazines			
Professional Newsletters			
Government Reports			
Vendor Material & Data			
Unpublished Papers			
Indices & Abstracts			
Automated Info. Systems			
Other*			
VERBAL:			
Colleagues			
Subordinates			
Superiors			
Consultants			
Librarians			
Other*			
COMBINATIONS:			
Meetings - Inside			
Meetings - Outside			
Personal Files			
Organizational Files			
Libraries			
Other*			
METHOD:			
Long Distance Calls			
Local Calls			
Correspondence			
Copying Equipment			
Other*			

NS PM-III 6.5, Revision 1, August 16, 1966

Figure 8

Third Session

is brought by an assistant from the library" is difficult. Current attempts are directed at developing a multi-dimensional taxonomy.

Four dimensions are currently being explored; their naming and explicit definition is yet to come. The first dimension is concerned with knowledge or information which the scientist needs to carry out his research. It may be a critical element for a decision, it may be confirmation or rejection of existing knowledge, it could change utilities or expectation or it could help explain an unexpected result. These are all in the cognitive domain. The dimension could be called "knowledge, information or cognitive inputs."

The second dimension describes long-term and re-addressable storage of items from Dimension 1. These would include books, journals, IBM cards, letters, memos, wall charts, handbooks, desk memories, magnetic tapes, reports, abstracts, and Xerox copies. The second dimension could be called "sources, containers, indices, permanent retainer or storage."

The third dimension could be part of the record if one wished to consider temporary storage as being part of the dimension. Techniques of transmission, reproduction and temporary storage are covered, i.e., a Xerox machine, telephone, TV, a core memory unit or a U.S. mailman. This dimension, in addition to temporary storage, could be called "information techniques or information processing."

The fourth dimension involves combining items from the other dimensions. Libraries, consulting organizations, files and information systems, for example, all combine many different items and new configurations. These combinations generally contain several sources, media and other combinations. Men are generally important in programming, maintaining and operating them. This dimension we have considered naming "organizations, aggregations, combinations, higher level information suppliers."